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SPECIFICITY, GEOGRAPHIC DISTRIBUTIONS, AND FOODPLANT DIVERSITY IN FOUR *CALLOPHRYS* (*MITOURA*) (LYCAENIDAE)

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ABSTRACT. The species *C. siva*, *gryneus*, *hesseli*, and *turkingtoni* are examined. Genitalic evidence of their non-conspecificity is provided along with discussion of particular localities of sympatry. Detailed distributional data are illustrated and a documented table of foodplant diversity included. *C. siva* and *gryneus* are oligophagous on numerous species of *Juniperus* (Cupressaceae) which replace each other geographically across the United States. *C. hesseli* is monophagous on *Chamaecyparis thyoides* (Cupressaceae); the foodplant of *turkingtoni* is unknown. Evidence indicates that all local populations are specific to one foodplant species.

Callophrys (*Mitoura*) *nelsoni* (Boisduval), *C. siva* (Edwards), *C. loki* (Skinner), *C. gryneus* (Hübner), and *C. hesseli* (Rawson & Ziegler), aside from taxonomic descriptions, have been subject to several biological and regional studies, but published works (Anderson, 1974; Johnson, 1972; Pease, 1963; Rawson et al., 1951; Remington & Pease, 1955) are very heterogeneous in content and comprehensiveness.

During the last four years I have been compiling data on their distributions and larval foodplants as a base for taxonomic studies of the group. I have also been studying the genitalia of all Nearctic and Neotropical *Callophrys* (*Mitoura*) in detail (Johnson, 1976a). The purpose of this paper is to present detailed distributional data for three of these species (*C. siva*, *C. gryneus*, and *C. hesseli*), demonstrate that *C. siva* and *C. gryneus* are not conspecific, and summarize data on larval foodplants, a number of which are new to the literature. What biogeographical data are known on the newly named *C. turkingtoni* Johnson (Johnson, 1976b) will also be presented. The specificity of *C. siva* and *C. nelsoni* involves several complex problems in the northwestern United States and will be treated in a separate paper (Johnson, 1977).

METHODS AND MATERIALS

Using the collection of the American Museum of Natural History as a basis, additional information on localities and possible local foodplants was gathered by correspondence and recorded county by county. Specimens or photographs were solicited in cases of peripheral or isolated populations, and available published records were included. The research aimed at definitive treatment on the species level only. Genitalic studies of males and females were performed in areas where *C. siva* and *C. gryneus* were reportedly sympatric. These genitalia were compared with those from many parts of the ranges of *C. siva* and *C. gryneus*, as well as with dissections of other congeners. The number of these specimen dissections included: *C. siva*, 78; *C. gryneus*, 46; *C. hesseli*, 14; *C. turkingtoni*, 1; *C. nelsoni*, 83; *C. rosneri*, 46 (Johnson, 1976a); *C. barryi*, 19 (Johnson, 1976a); *C. byrnei*, 9 (Johnson, 1976a), and *C. loki*, 15.

Geographic ranges were studied to discover areas of insect distribution not coinciding with present published foodplant knowledge, and efforts were then made to make the list for each species complete by identification of exact plants with which the adults were associated by perching behavior (Johnson & Borgo, 1976) or on which oviposition or larvae were observed. Full documentation of each of these methods is given in the foodplant table (Table 1) since a degree of fallibility has been demonstrated in each (Brower, 1958; Downey & Dunn, 1965). An ongoing effort to compile foodplant specimens at one institution was initiated, and plants collected thus far are cited in the table. Since the perching behavior of these insects limits general flight patterns to the vicinity of the foodplant, and since data not only in this study but another (Johnsonn, in prep.) indicate that *C. siva* and *C. gryneus* are exclusive *Juniperus*-feeders, some useful evidence on larval foodplants in areas where only one juniper species was regionally present could be culled from identification of the plants at the locality indicated on the specimen labels.

The list of plants established as the only *Juniperus* species present in a region (R) or at a locality (L), source of butterfly data (B), source of plant data (P) is:

C. siva: *Juniperus deppeana* Steud., (L) 10 mi. NW Pine Springs, Culberson Co., Texas, (B) R. O. Kendall, (P) Herbarium, University of Texas, Austin; *J. deppeana*, (L) 5 mi. W of McDonald Observatory, Jeff Davis Co., Texas (B) R. O. Kendall, (P) Herbarium, University of Texas, Austin. *Juniperus occidentalis occidentalis* Hook. × *J. osteosperma* Torr. (Little), (R) Washoe Co., Nevada (Reno and vicinity westward), Ormsby and Douglas cos., (B) P. Herlan, (P) Vasek, 1966. *Juniperus monosperma* (Engelm.) Sarg., (L) Sycamore Canyon, NW of Nogales, Santa Cruz Co., Arizona, (B) Share and Clark (American Museum of Natural History (AMNH)), (P) Herbarium, Arizona State University, Tempe. *Juniperus pinchotii* Sudw., (R) Reeves Co., Texas, (B) D. Stallings and M. R. Turner, (P) Adams, 1972, R. P. Adams, pers. comm. *C. gryneus*: *Juniperus virginiana* L., (R) Cass Co., Texas, (B) R. O. Kendall, (P) Adams & Turner, 1970, R. P. Adams, pers. comm. *Juniperus ashei* Buchholz, (R) McLennan Co., Texas, (B) R. O. Kendall, (P) Adams, 1972; Adams & Turner, 1970; R. P. Adams, pers. comm. *Juniperus pinchotii* Sudw., (R) Pecos Co., Texas, (B) R. O. Kendall, (P) Adams, 1972, R. P. Adams, pers. comm. *Juniperus deppeana* Steud., (L) Huejotitlan, Chihuahua, Mexico, (B) AMNH, (P) Little, 1971. *J. deppeana*, (L) Baboquivari Mountains, S of Baboquivari Peak, Pima Co., Arizona, (B) J. D. Gunder (AMNH), (P) Herbarium, Arizona State University, Tempe. *Juniperus virginiana* L. × *J. horizontalis* Moench., (L) Lynxville, along Mississippi River,

TABLE 1. Larval foodplants established by the identification of exact plants.

Foodplant taxa and specimens	Butterfly taxa and specimens
Callophrys (Mitoura) siva	
Juniperus scopulorum Sarg.[1] Plants, PL: Van Haverbeke, N-2; hybrid index at site—63 ± 8% *J. scopulorum*; SL: Johnson, 1972.[2] Plant specimens, K. Johnson #2 (Smiley Canyon = VanH. N-2; #1 (Chadron), Royal Ontario Museum, Toronto (ROM).[3]	*s. siva*; Dawes Co., Nebraska (Smiley Canyon), W of Fort Robinson; Catholic Cemetery, Chadron.[4] Butterflies, PC (AC, O, B)[5]: K. Johnson (AMNH).[6]
Juniperus scopulorum var. *columnaris* Fasset Plants, PL: Van Haverbeke ND-8, I: T. McCabe, (H) North Dakota State Univ., Fargo; SL: Van Haverbeke, 1968. Plant specimens, Van Haverbeke ND-8, Univ. of Nebraska (UN).	*s. siva*; Slope Co., North Dakota (Amidon, along burning coal vein). Butterflies, PC: T. McCabe.
Juniperus scopulorum Sarg. × *J. virginiana* L. Plants, PL: Van Haverbeke N-7; hybrid index at site—48 ± 6% *J. scopulorum*; Range of use of hybrids (Johnson, 1972)—70 ± 4% to 36 ± 4% *J. scopulorum.* Plant specimens, Van Haverbeke N-7, UN; K. Johnson #3 (Sizer, Keith Co.) ROM.	*s. siva*; Garden Co., Nebraska (bluffs above N. Platte River, nr. Lewellen). Butterflies, PC (AC): L. Running, AMNH.
Juniperus virginiana L. Plants, 17 mi S of PL: Van Haverbeke N-4; hybrid index at site—36 ± 4% *J. scopulorum*; SL: Johnson, 1972. Plant specimens, Van Haverbeke N-4, UN; K. Johnson #4 (locality as above) ROM.	*s. siva*; Rock Co., Nebraska (Long Pine Rec. Area). Butterflies, PC (AC, LC, B): K. Johnson, L. Running, AMNH.
Prostrate morph of *J. scopulorum* Sarg. × *J. virginiana* L. × *J. horizontalis* Moench.	*s. siva*; Saskatchewan, Canada (Val Marie, near Rosefield along Frenchman River).

[1] Taxon of foodplant used (according to nomenclature of USDA (1953) and Little (1971)).
[2] Source of plant data: PL = butterflies were specifically collected at a particular locality studied by Cupressaceae taxonomists; their designation of the site is noted along with the date of their study. "Hybrid index" refers to these studies' calculation of the degree of hybridity in plants at these areas. Plant identifications are noted as "I": I, exact substrate plant identified by ______ (H = Herbarium at ______), and location of voucher specimens; I_1, plant identified by data sent to ______ by ______; I_2, foodplant established in original description of butterfly, citation given; I_3, plant identified from specimens sent to ______; I_4, substrate plant established by matching herbarium specimens with butterfly data and establishing that no other species co-occurs, herbarium cited. An "*" following this category ("Plants") means this foodplant usage is well known; SL = other literature which supports this identification.
[3] The label number and place of deposition of plant specimens collected in this study An "*" means collection in progress at time of this writing.
[4] Taxon of butterfly concerned (as designated in annotated list), with state and exact locality.
[5] Source of butterfly data: PC = "personally collected by ______." Letters in parentheses following mean: AC, adults commonly observed perching; AI, adults perching but not commonly observed; LC, larvae collected; LO, larvae observed; B, behavior studied in detail; O, oviposition observed.
[6] Location of specimens if not aforementioned person (AMNH = the American Museum of Natural History, New York). M = museum specimens were used as the source of data; ver. means verified by ______, and method. TL = type locality of the insect.

TABLE 1. *Continued*

Foodplant taxa and specimens	Butterfly taxa and specimens
Plants, Schurtz (1971) indicates this area would be included in his tri-parental swarm. Van Haverbeke (pers. comm.) supports this evaluation; I: (H) Univ. Saskatchewan, Regina; I_1: D. F. Van Haverbeke (data from R. Hooper, K. Johnson); SL: Little, 1971; Van Haverbeke, 1968; Fassett, 1945. Plant specimens, (H) Univ. Sask. (Sask. Prairie Park); K. Johnson #5* (Hooper) ROM.	Butterflies, PC (AC): R. Hooper (ver. K. Johnson, photo).
Juniperus osteosperma (Torr.) Little Plants, I_3: D. F. Van Haverbeke; SL: Emmel & Emmel, 1973; Johnson, 1977; Little, 1971. Plant specimens, K. Johnson #15 (Running, locality as above) AMNH.	*s.* ssp.; White Pine Co., Nevada (nr. McGill Junction). Butterflies, PC (AC): L. Running, AMNH.
Juniperus californica Carr. Plants +, I_3: D. F. Van Haverbeke; SL: Comstock, 1927; Emmel & Emmel, 1973. Plant specimens, K. Johnson #16 (Leone, locality as above) AMNH.	*s. juniperaria*; Los Angeles Co., California (Mint Canyon). Butterflies, PC (AC): M. Leone, AMNH.
Juniperus occidentalis occidentalis Hook. Plants, I_3: D. F. Van Haverbeke; SL: Johnson, 1977, Little, 1971. Plant specimens, K. Johnson #17 (Buckingham, locality as above).	*s.* ssp.; Jefferson Co., Oregon (nr. Warm Springs, W on road to Twin Buttes). Butterflies, PC (AC): F. Buckingham, AMNH.
Juniperus occidentalis australis Vasek Plants, I: John H. Lane; SL: Vasek, 1966.	*s.* ssp.; Tulare Co., California (vic. Kennedy Meadows), San Bernardino Co., California (Big Bear Lake). Butterflies, PC (AC): John H. Lane.
Callophrys (*Mitoura*) *gryneus*	
Juniperus virginiana L. Plants, I: K. Johnson; SL: Klots, 1951, Little, 1971. Plant specimens, K. Johnson #21 (locality as above).	*g. gryneus*; Ulster Co., New York (West Park, Holy Cross Publications). Butterflies, PC (AI): K. Johnson, AMNH.
Juniperus silicicola (Small) Bailey Plants, I: F. D. Fee, (H) Univ. Florida, Gainesville; I_1: (H) Univ. Gainesville; SL: Klots, 1951; Little, 1971. Plant specimens, K. Johnson #10 (St. Augustine locality, Univ. Florida) ROM.	*g. sweadneri*; St. Johns Co., Florida (along Ocean Rt. A1A, St. Augustine). Butterflies, PC (AC): F. D. Fee.
Juniperus scopulorum Sarg. × *J. virginiana* L. Plants, PL: Van Haverbeke M-1; hybrid index near site—27 ± 4% *J. scopulorum*; Range of use of hybrids (Johnson,	*g. gryneus*; Jackson Co., Missouri (general). Butterflies, PC (AC): J. R. Heitzman.

TABLE 1. *Continued*

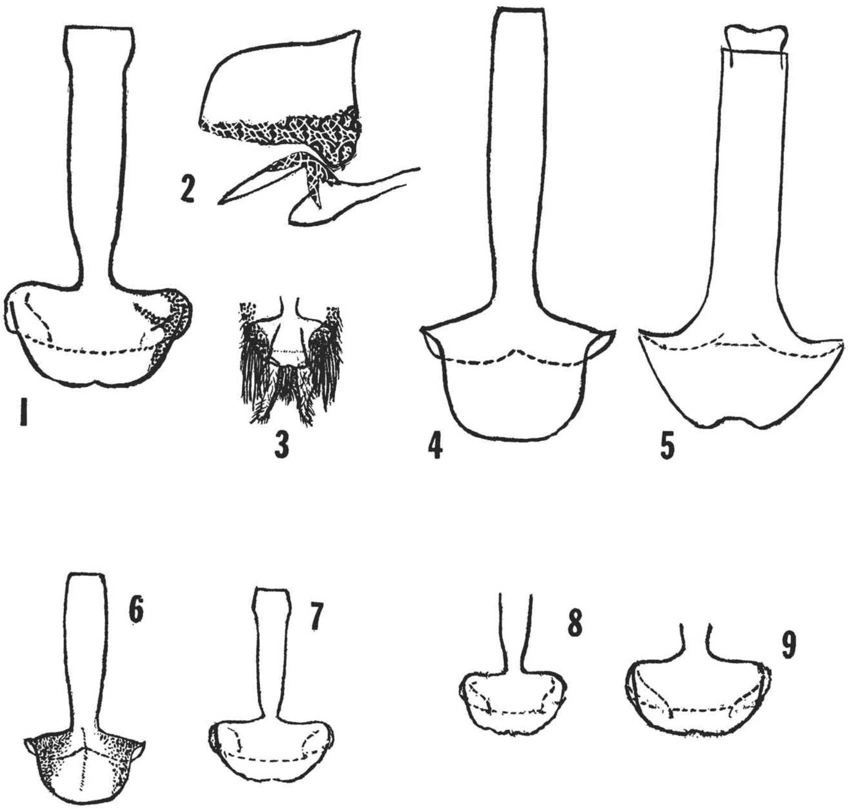
Foodplant taxa and specimens	Butterfly taxa and specimens
1972)—38 ± 4% *J. scopulorum* to 27 ± 4% *J. scopulorum.* Plant specimens, K. Johnson #11 (Heitzman, Independence) ROM.	
Juniperus ashei Buchholz Plants, I: J. R. Heitzman; SL: Little, 1971. Plant specimens, K. Johnson #12* (Heitzman, ?) ROM.	*g.* ssp.; Barry Co., Missouri (Eagle Rock), also McDonald Co.; Washington and Carroll cos., Arkansas. Butterflies, PC (AC): J. R. Heitzman.
Juniperus pinchotii Sudw. Plants [two examples], I_1: R. P. Adams (Scott, Roever); SL: Adams, 1972.	*g. castalis* [two examples]; Armstrong Co., Texas (just below N rim of Palo Duro Canyon, 15–16 mi. S Claude).
I: R. O. Kendall; SL: Little, 1971; Adams & Turner, 1970.	Butterflies, PC (AC): M. Toliver, H. A. Freeman, J. M. Burns, K. Roever (R. O. Kendall); J. Scott. Bexar Co., Texas (Reo Seco Road, off U.S. Hwy. 281 N of San Antonio). Butterflies, PC (AC, O): R. O. Kendall.
Juniperus virginiana L. × *J. horizontalis* Moench. Plants, I: (by reason of Schurtz, 1971) D. F. Van Haverbeke; SL: Schurtz, 1971; Little, 1971. Plant specimens, K. Johnson #13 (locality as above).	*g. gryneus*; Dane Co., Wisconsin (10 mi. W of Madison). Butterflies, PC (AC): W. Sieker.
Callophrys (Mitoura) hesseli	
Chaemaecyparis thyoides (L.) B.S.P. Plants*, I: S. Hessel, G. W. Rawson, J. B. Ziegler; I_2: Rawson et al., 1952; Rawson & Ziegler, 1950 (therein det. by I. M. Johnston, Harvard Univ.).	*hesseli*; Ocean Co., New Jersey (Lakehurst, TL). Butterflies, PC (AC, LO, LC): S. Hessel, G. W. Rawson, J. B. Ziegler.

Lacrosse Co., Wisconsin and 5 mi. W of Sauk City, Sauk Co., Wisconsin, (B) F. Arnold and W. E. Sieker, (P) Ross & Duncan, 1949; Schurtz, 1971; D. F. Van Haverbeke, pers. comm. *C. turkingtoni*: *Juniperus flaccida* Schlecht., (R) 10 mi. E of Namiquipa, Chihauhua, Mexico, (B) W. Gertsch and M. Cazier (AMNH), (P) Little, 1971; Herbarium, University of Mexico, Mexico City.

RESULTS

Genitalia of *C. gryneus* and *C. siva*

Genitalia of males and females were studied in three regions where these species were reportedly sympatric (Davis Mountain, Texas; Guadalupe Mountains, New Mexico and Texas; and Baboquivari Mountains, Arizona) and found to be easily separable. However, some traditionally

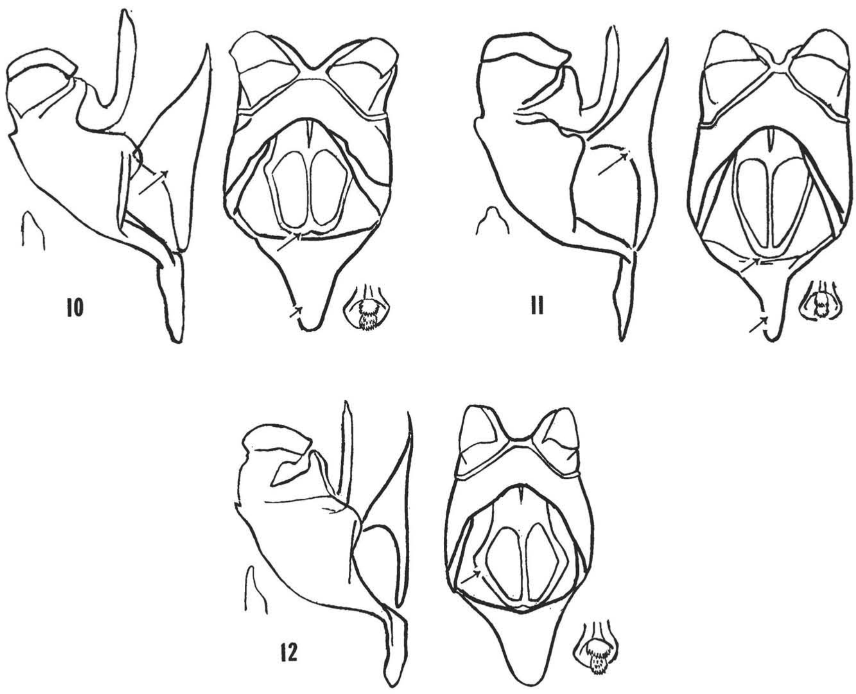


Figs. 1–9. Female genitalia of selected Nearctic *Callophrys* (*Mitoura*) spp. *C. siva siva*: 1, topotypical; 2, heavily sclerotized areas of lamellae and eighth sternite; 3, showing tufts of "hair" allowing diagnosis by naked eye. *C. gryneus*: 4, topotypical. *C. hesseli*: 5, topotypical. Genital plates of sympatric species near Alpine, Texas: 6, *C. gryneus* and 7–9, *C. siva.*

used wing-pattern characters for distinguishing these species (ventral secondaries: post basal spots or pattern of mesial band) were shown to be less reliable (also noted in Johnson, 1976a, 1977). The diagnostic genitalic characters are as follows:

Females (Figs. 1–9). *C. gryneus* (Figs. 4, 6): ductus bursa longer and not "club-ended" as on *siva*; lamellae tapering caudad from antrum, not shouldered as on *siva*, lamellae postvaginalis nearly as long as broad; juncture of lamellae and eighth abdominal sternite not heavily sclerotized or connected.

C. siva (Figs. 1–3, 7–9). Ductus bursa shorter than *gryneus* and "club-ended"; lamellae distinctly shouldered, lamella postvaginalis much broader than long. Juncture of lamellae and eighth abdominal sternite heavily sclerotized, in area between



Figs. 10–12. Male genitalia of selected Nearctic *Callophrys* (*Mitoura*) spp., lateral and posterior views with tip of aedeagus (right) and falces (left): 10, *C. gryneus castalis*, topotypical; 11, *C. siva siva*, topotypical; and 12, *C. hesseli*, topotypical.

l. postvaginalis and l. antevaginalis forming bulkly ridges and convolutions at their juncture, these binding lamellae tightly with eighth abdominal sternite and containing many spines.

[*C. hesseli* (Fig. 5). Easily recognized by unique shape of the lamellae and broad cephalad tapering from the antrum (figured for reference). *C. turkingtoni*: female unknown.]

Males (Figs. 10–12). *C. gryneus* (Fig. 10). Valvae, lateral shape: only barely concave between dorsal and ventral articulation with vinculum; valvae, caudad saccus (dorsal or ventral view): rounded and indented, vaguely shouldered caudad. Saccus: long and broad.

C. siva (Fig. 11). Valvae, lateral shape: deeply concave and rounded between dorsal and ventral articulation with vinculum; valvae, caudad saccus (dorsal and ventral view): parabolic and unindented, no shouldering caudad. Saccus: short and much less broad than *gryneus*.

[*C. hesseli* (Fig. 12). Lateral shape of valvae less broad, quite concave between articulations with vinculum, and much longer caudad; valvae caudad saccus broadly round, indented, and extremely shouldered caudad (figured for reference). *C. turkingtoni* (Johnson, 1976a), easily recognized by extremely long caudad extension of valvae and by heavily sclerotized and spiny area of valvae, caudad saccus.]

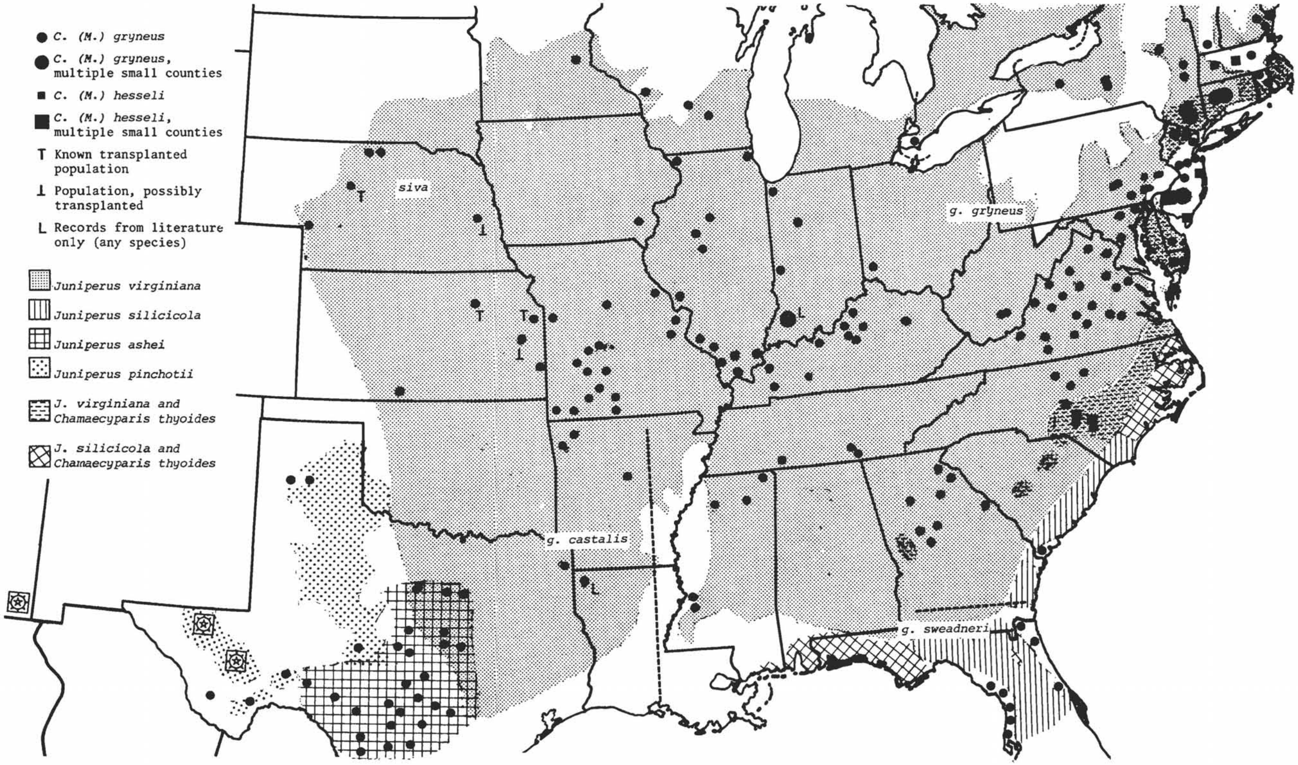


Fig. 13. Nearctic distributions of *Callophrys* (*Mitoura*) *gryneus* and *C.* (*M.*) *hesseli* and their larval foodplants, *Juniperus* and *Chamaecyparis*. Starred squares indicate sympatric populations of *C.* (*M.*) *gryneus* and *C.* (*M.*) *siva* diagnosed by genitalic traits. Confusion in current common usage of trinomes only allows for general regional indication as shown by names and broken lines. Plant distributions adapted from Adams & Turner, 1970; Little, 1971; and Adams, 1972.

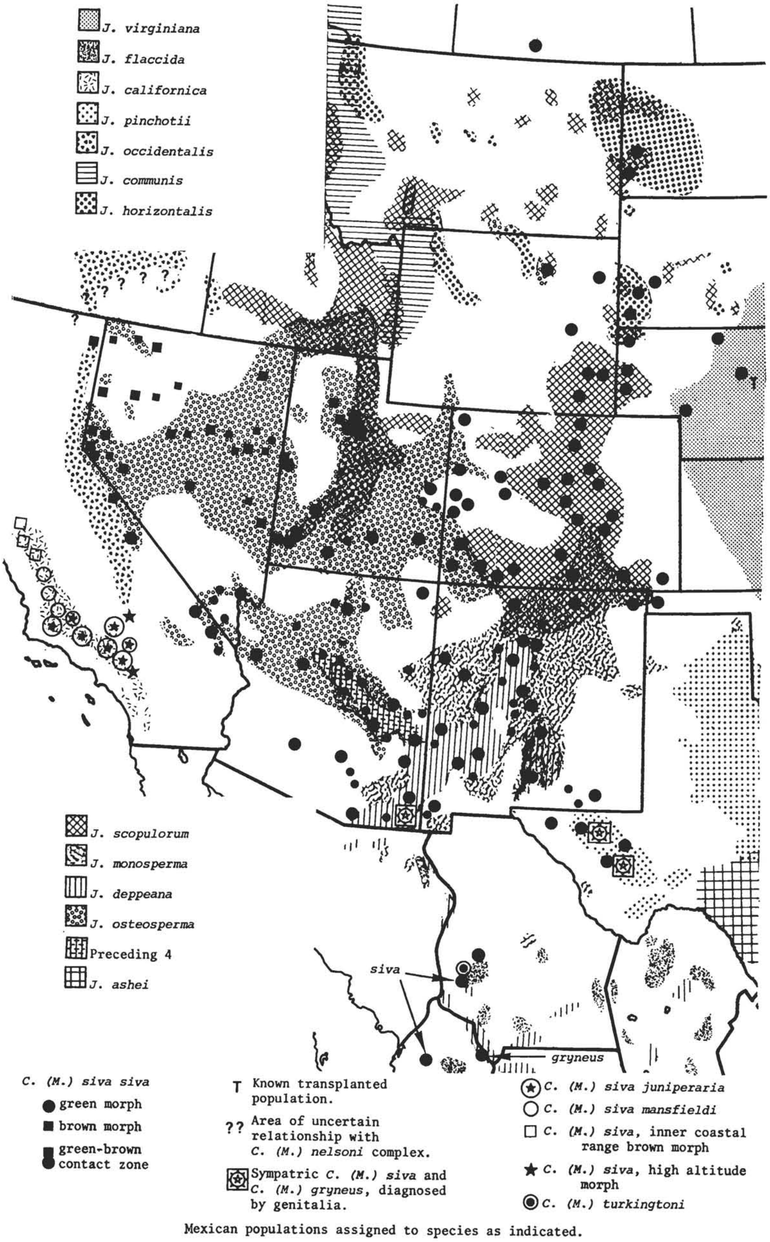


Fig. 14. Nearctic distributions of *Callophrys* (*Mitoura*) *siva* and its larval foodplant *Juniperus* spp., and known range of *C.* (*M.*) *turkingtoni*. Plant distributions adapted from Little, 1971. Distribution of *Juniperus horizontalis* shown only as it exceeds *J. scopulorum* northward; hybrid swarms of *Juniperus* spp. illustrated in Fig. 15.

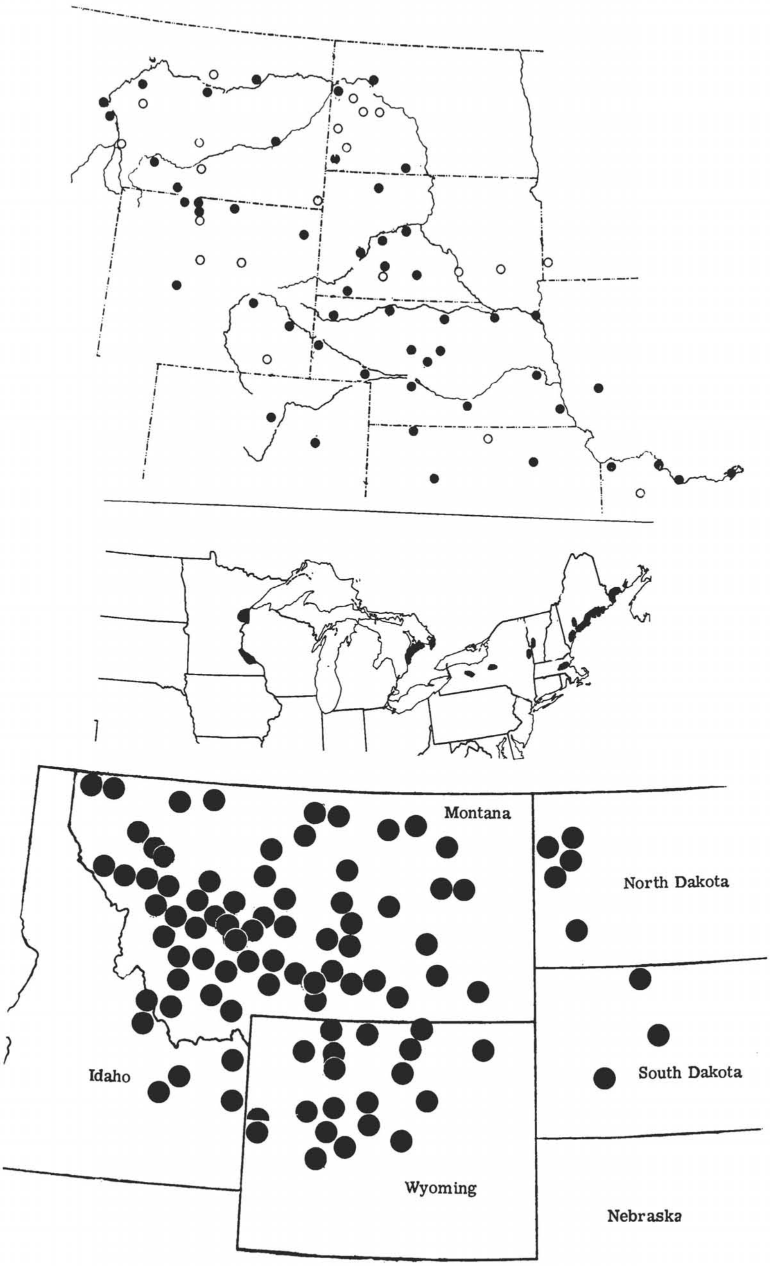


Fig. 15. Bi-parental and tri-parental swarms of divergence in Nearctic *Juniperus*: top, localities indicated by Van Haverbeke (1968) as "hybrid" *J. virginiana* × *J. scopulorum*; center, parental areas of *J. horizontalis* indicating possible centers for

Geographic Distributions and Available Larval Foodplants

Figs. 13 and 14 show the Nearctic distributions of species of *Callophrys* (*Mitoura*) in relation to the ranges of available or established larval foodplants. Fig. 15 shows areas of *Juniperus* ranges that have been botanically demonstrated as "hybrid swarms" (Van Haverbeke, 1968; Schurtz, 1971).

Summary of Data and Current Taxonomic Usages

The following is a review of the current common usage of trinomens in each group with a summary that includes distribution, foodplant(s) as established in this paper, general comments on the phenotype, and notes on the particular significance of each population. Where populations are under study by other lepidopterists, and especially where they are planning to assign new names, I have called these subspecies "ssp." and included the appropriate investigator's name in brackets.

Annotated List

Callophrys (*Mitoura*) *siva*

C. (*M.*) *siva siva*. Type locality: Fort Wingate, McKinley Co., New Mexico. Distribution: Workers have named populations distinct from this taxon only on the West Coast, although others are undoubtedly present. Phenotype: There are two general morphs, based on ground color of the ventral secondaries. Great Basin populations (Fig. 14, squares) are brown beneath, whereas others (Fig. 14, plain black circles) are green. Populations of green-browns and mixed greens and browns occur in western Utah (Fig. 14, overlapping square and circles). The brown morph, which Peter Herlan, H. K. Clench, and I have investigated (Johnson, in prep.), is separately treated below. Foodplants: Many western *Juniperus* species (see Table 1) replace each other geographically. "Hybrids" (see Summary and Conclusions) of *J. virginiana* × *J. scopulorum*, *J. virginiana* × *J. horizontalis*, and *J. virginiana* × *J. scopulorum* × *J. horizontalis* (possibly also *J. occidentalis* × *J. osteosperma*) occur in western Nevada, adjacent California, and eastern Oregon. All populations of *Callophrys siva* are on erect trees except for one local population (Val Marie, near Rosefield, Saskatchewan, along Frenchman River) on prostrate plants.

C. (*M.*) *siva* ssp. [Johnson, in prep.]. The research of Herlan, Clench, and Johnson involves naming this Great Basin population. Distribution: southern Nevada northward to Idaho; brown eastward to Salt Lake City; brown westward to southeast Oregon; broad interface with green morph *C.* (*M.*) *siva siva* in western Utah (e.g., Eureka, Dividend, Provo, western Millard Co.). Foodplants: Herlan reported *J. osteosperma*, but probably *J. osteosperma* × *J. occidentalis* near Reno, Nevada (Vasek, 1966). Apparently not *J. scopulorum* where it is available, al-

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"hybrid" status with *J. virginiana*; bottom, localities indicated by Schurtz (1970) as "hybrid" *J. virginiana* × *J. scopulorum* × *J. horizontalis*.

though Idaho occurrences of *C.* (*M.*) *siva* may be lacking due to inadequate sampling.

C. (*M.*) *siva juniperaria* (Comstock). Type locality: Los Angeles Co., California. Distribution: western San Bernardino, northern Los Angeles, eastern Kern, and southern and northern Inyo cos.; transition with next subspecies in northern Ventura and northeastern Santa Barbara cos. Foodplant: *Juniperus californica* throughout its range, but in one locality (areas between Phelan and the San Gabriel Mountains, close to the Los Angeles, San Bernardino county lines) it is known to perch also on *J. osteosperma* (J. Lane, pers. comm.).

C. (*M.*) *siva mansfieldi* (Tilden). Type locality: Simmler, San Luis Obispo Co., California. Distribution: southern California—western Kern and eastern San Luis Obispo cos. This is somewhat northward of the preceding subspecies. This taxon is ill-defined from that immediately below. Phenotype: deep green morph. Foodplant: *J. californica.*

C. (*M.*) *siva* ssp. [Lane, A]. Distribution: north of the preceding entity in the south inner coastal range of California (northern San Luis Obispo, southwestern Fresno, San Benito, eastern Santa Clara, and western Contra Costa cos.). Phenotype: brown morph. Foodplant: *J. californica.*

C. (*M.*) *siva* ssp. [Johnson, in prep.]. The identity of reputed *C.* (*M.*) *siva* specimens from eastern Oregon and Washington to western Idaho, and their relation to the name *C.* (*M.*) *nelsoni*, has been resolved by detailed genitalic studies (Johnson, in prep.). Populations in nearly all of Oregon east of the Cascades to extreme southwest Idaho and extreme southeastern Washington are *C. siva.* Phenotype: burgundy-brown morph. Foodplants: Oregon, Washington—*J. occidentalis*; Idaho—*J. osteosperma.* The taxon in press by Johnson includes only the *J. occidentalis* utilizers; those on *J. osteosperma* represent northward range of another subspecies distributed throughout Nevada and reviewed above.

C. (*M.*) *siva* ssp. [Lane, B]. Distribution: High altitudes in the southern Sierra Mountains (e.g., Kennedy Meadows, Tulare Co., California) and San Bernardino Mountains (e.g., Big Bear Lake, San Bernardino Co., California). Phenotype: green morph. Foodplant: *J. occidentalis australis.*

Callophrys (*Mitoura*) *gryneus*

C. (*M.*) *gryneus gryneus.* Type locality: Rappahanock Co., Virginia. Distribution: eastern and central North America in scattered populations wherever *J. virginiana* occurs. Phenotype: green morph. Foodplants: *J. virginiana*, but not observed feeding on sympatric *J. communis*, prostrate morphs of *J. horizontalis* × *J. virginiana*, or prostrate morphs of *J. horizontalis* northward; however, apparently utilizes erect morphs of *J. horizontalis* × *J. virginiana* (see Summary and Conclusions). Particular note: sometimes collected on nectar sources with *C.* (*M.*) *hesseli*, but foodplants are segregated by habitat in nature and not interchangeable.

C. (*M.*) *gryneus sweadneri* (Chermock). Type locality: St. Augustine, St. John's Co., Florida. Distribution: Florida, perhaps southern Georgia, and north along the Atlantic Coast where *J. silicicola* occurs. Phenotype: green morph. Foodplant: *J. silicicola.*

C. (*M.*) *gryneus castalis* (Edwards). Type locality: McLennan Co., Texas. Distribution: mainly Texas, but also Chihuahua, Mexico, and areas west of the Mississippi River "gap" in juniper ranges; in addition, used by some workers as a form name within eastern United States populations. Phenotype: green morph. Foodplants: *J. virginiana, J. ashei,* and *J. pinchotii,* replacing each other westward. *J. deppeana* and possibly *J. flaccida* in Mexico.

C. (*M.*) *gryneus* ssp. [Johnson, in prep.]. Distribution: the Baboquivari Mountains eastward into Cochise Co., Arizona, and possibly southward in disjunct ranges of *J. deppeana.* Phenotype: green morph. Foodplant: *J. deppeana* suspected.

Callophrys (Mitoura) hesseli

C. (M.) hesseli. Distribution: see Fig. 13. Phenotype: green morph. Foodplant: *Chamaecyparis thyoides*.

Callophrys (Mitoura) turkingtoni

C. (M.) turkingtoni, a single specimen known from Namiquipa, Chihuahua, Mexico, in habitat of *J. flaccida*. Phenotype: brown morph.

SUMMARY AND CONCLUSIONS

Interspecific relations. Studies of *C. siva* and *C. gryneus* at several sympatric localities (21 specimens from the Baboquivari Mountains, Pima Co., Arizona; Cochise County (general), Arizona; Guadalupe Mountains, Eddy and Otero cos., New Mexico, Culberson Co., Texas; and Alpine, Brewster Co., Texas) confirmed that they are separable by genitalia of the males and especially the females (Johnson, in prep.). Since town, county, or mountain range is the only data available on some of these specimens, the extent of their microallopatry or microsympatry remains unknown. Biogeographic data suggest that the species may be altitudinally separated at some localities in Texas (*C. siva* on higher altitude *J. deppeana*, *C. gryneus* on lower altitude *J. pinchotii*), but it is likely that interspecific competition occurs at some locations. Sharing of nectar sources may occur, as reported in *C. gryneus* and *C. hesseli* (J. B. Ziegler, pers. comm.). These two species are generally segregated by the habitats of their foodplants. The female genitalia of *C. hesseli* have not been previously figured in the literature and are included in Fig. 5.

Foodplant relations. *C. siva* and *C. gryneus* utilize a broad spectrum of related and equally acceptable *Juniperus* species, which replace or exceed each other in geographic distribution over the Nearctic Realm. There is evidence that every species of *Juniperus* in the Nearctic is utilized, with two exceptions: *J. communis* L. and *J. horizontalis* Moench. Van Haverbeke (1968) and especially Schurtz (1971) have shown that *J. horizontalis* is actually part of a broadly distributed "swarm of divergence" which involves the parental stock to which the names *J. virginiana*, *J. scopulorum*, and *J. horizontalis* have been applied. Van Haverbeke (pers. comm.) prefers Schurtz's interpretation that each of these merits species status but that they are tied by their evolutionary histories, *J. virginiana* being an eastward evolutionary manifestation of *J. scopulorum* and *J. horizontalis* being a northward evolutionary manifestation of this biparental parent stock. Thus, there is little chemical or morphological reason (unless it is the number of needles versus fleshy leaves) that would prevent use of *J. horizontalis* by these *Callophrys (Mitoura)* especially where it is sympatric with utilized *J. virginiana* or *J. scopu-*

lorum. Johnson & Borgo (1976) have shown that the perching behavior of *C. siva* and *C. gryneus* is distinctly patterned and preferenced for heights. They postulate that the nature of this patterned perching behavior selects against prostrate morphs and is at least a partial boundary on their usage as a larval foodplant (Johnson & Borgo, 1977). The importance of the number of needled leaves on both *J. horizontalis* and *J. communis* needs investigation since first instar larvae burrow into these to feed.

Knowledge of the local specificities of the two oligophagous species is quite incomplete, although preliminary evidence from several localities indicates that populations are specific to particular plant species. In Palo Duro Canyon (Randall and Armstrong cos., Texas) *J. scopulorum, J. pinchotii, J. monosperma*, and hybrids of the latter two occur (Adams, 1972, and pers. comm.). Field data from collectors of *C. gryneus* indicate that *J. pinchotii* is the only foodplant. However, verification is needed by someone who can test this hypothesis directly. Peter Herlan (pers. comm.) reports that the Great Basin brown morph of *C. siva* feeds exclusively on *J. osteosperma.* Perhaps this is true, but Vasek (1966) has suggested that this species introgresses with *J. occidentalis* westward, and the taxonomic relationships of *C. siva* in the northwest basin are now indicated as including two, largely disjunct subspecies, one feeding on *J. occidentalis* in central and eastern Oregon and the other on *J. osteosperma* in Nevada eastward to Utah. In Missouri and Arkansas, *C. gryneus* populations are located on *J. ashei* where it occurs as "islands" within the range of *J. virginiana.* Other *C. gryneus* populations are on *J. virginiana.* This is another location ideal for specificity studies, as are the areas of diversity of juniper species in Arizona and New Mexico. In California, John Lane reports (pers. comm.) *C. siva juniperaria* perching on both *J. osteosperma* and *J. occidentalis* in an area where *J. occidentalis* has been reported as the foodplant. Thus, foodplant relations in *C. siva* and *C. gryneus* mirror situations reported in Burns (1964), Downey (1966), and Downey & Dunn (1965). Local specificities are due to oviposition by the female on the plant species it fed on as a larva. Thus, according to the familiar "Hopkins' Host Principle," specificity is maintained. However, it is obvious that alterations do occur through time and space (as the above authors also indicate), and this is why such species show catholicity when their foodplant usage is viewed as a whole. The mechanism of ovipositional specificity and the nature of chance alterations need further elucidation. Downey & Dunn (1965) suggest that the patterning of Hopkins' Host Principle is not genetic but physiological and undergoes divergence, convergence, and parallelism through time and space. The present study indicates that similar foodplants available as replacers offer opportunity for divergence, since nearly all barriers posed to these insects by replacer plants have been crossed. Similarly, the remarkable coincidence of distinguishable morphs or subspecies generally within the distribution of one or another foodplant or foodplant relative suggests that foodplant adaptations play an important role in subspeciation. *Callophrys gryneus sweadneri* inhabits the areas of *J. silicicola*, *C. gryneus gryneus* those of *J. virginiana*, and *C. gryneus castalis* those of the transition of the latter plant to the ranges of *J. ashei* and *J. pinchotii*. Relations in the *C. siva* complex, although trinomial knowledge is less complete, are equally distinctive. If one assumes monophagous *C. hesseli* evolved through adaptations of some populations of early *C. gryneus* stock to *Chamaecyparis thyoides*, a similar mechanism is imaginable, especially since *C. thyoides* and *J. virginiana* have undergone a change in their degree of sympatry through time (M. Rosenzweig, pers. comm.) in which populations of *C. thyoides* are now somewhat disjunct, and those of *C. hesseli* apparently extremely so.

Laboratory foodplant experiments with these species have not been extensive, and such data is of limited use in drawing inferences about foodplant utilization or preference in nature (Downey & Dunn, 1965; Downey & Fuller, 1962). However, studies to date indicate that quite divergent Cupressaceae species are at least nutritionally adequate and otherwise edible by some of the *Callophrys* (*Mitoura*) species. There is a need to further clarify the reported acceptance of *J. virginiana by* larvae of *C. hesseli*.

Distributional relations. One comment on the distribution of these insects, with regard to the frequency of transplanted populations is appropriate at this time. Cupressaceae species are widely used both in agricultural and landscape planting, and a number of transplanted *Callophrys* (*Mitoura*) populations have been noted (Figs. 13 & 14). Taxonomists should be especially aware of this when studying the comparative morphology of these butterflies. The occurrence of *C. siva* in planted forest well isolated in central Nebraska, where juniper is raised from Rocky Mountain stock, is an extreme example, as is the occurrence of this insect in a shelter belt along the Missouri River.

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